Metrology with Cooled Modules

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Introduction

The SCT barrel modules are being built at room temperature. The SCT working environment is designed to be at 0 C. The temperature difference motivates a concern about the possible module deformation. The issue may be more relevant with a LBL-proposed gluing pattern, where the line of glue dots along the gap between the sensors is not symmetric relative to the top-to-bottom flip. To investigate the effect, we surveyed two modules both at room temperature and at 0 C. One of the modules (E3) was built with the standard SCT glue pattern. Another one (Q5) was built with the LBL glue pattern.

Setup and Measurements

To have the module cooled down in a good environment, we took a module survey box (usually used for electrical testing), and adopted it for the SmartScope survey. The adaptation included three 5mm ruby balls to fix the box on the metrology table. This is the same scheme used with our regular metrology fixture. One ball sits on top of a round cone, thereby fixing one point in XYZ. Second ball sits in a groove, this constrains the XY rotation degree of freedom. The third ball sits on a plane, this fixes the plane orientation in 3D. The scheme is flexible enough to accommodate the thermal expansion or shrinkage without imposing mechanical stress on the box.

The box was cooled down through a dedicated cooling tube. To prevent the moisture condensation, a dry air flow through the box was established prior to the thermal cycle.

A picture of the setup is shown in Figure 1.

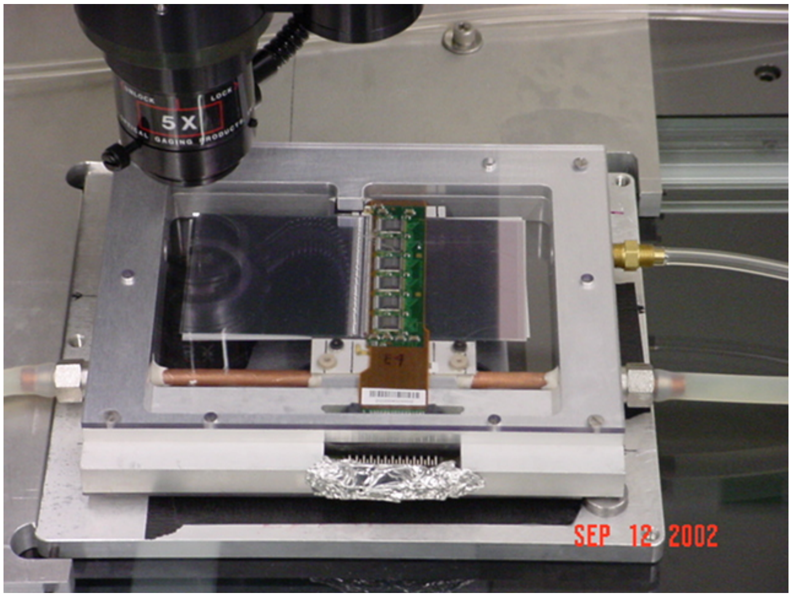

Figure 1. Module box is shown under survey on the SmartScope table. Also visible are the cooling and dry air pipes.

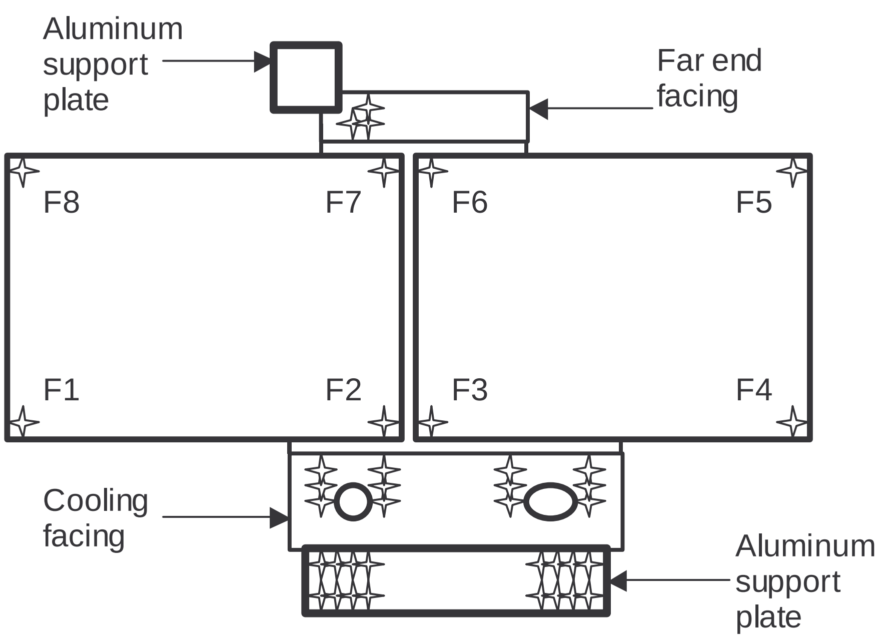

Figure 2. Schematics of the Z measurements. Stars indicate the measurements (focusing) points. The sensors fiducial marks are enumerated F1, F2, …, F8.

We measure the Z position of the following points:

- 16 points on the Al box support structure,
- 6 points on the cooling facing near the hole,
- 6 points on the cooling facing near the slot,
- 3 points on the far end facing,
- 8 points at the two sensors fiducial marks.

We work with the front side only. The measurements are done twice, at the room temperature of 24 C, and at 0 C.

With both modules, we've observed that the points on the Al support structure and Be facings move down very coherently when cooled. The variation of the Z travel from point to point was less than 3 microns. The points at the fiducial marks travel different amounts, as shown in Table 1.

Table 1. Z travel for selected points on the cooled module (Z(0 C) – Z(24 C)).

Point	**Z travel [microns]**	**Z travel relative to the facings [microns]**
Module E4 (standard glue pattern)		
Be facings and Al plate	–5	
F1	–10	-5
F2	–12	-7
F3	–14	-9
F4	–29	-24
F5	–20	-15
F6	–9	-4
F7	-8	-3
F8	-6	-1
Module Q5 (LBL glue pattern)		
Be facings and Al plate	–15	
F1	–47	-32
F2	–14	1
F3	–14	1
F4	–33	-18
F5	–31	-16
F6	–11	4
F7	-12	3
F8	-52	-37

With the underlying Al support plate thickness of 11 mm, we expect 6 microns shrinkage in Z. This is very close to the movement observed with E4, which has the right direction. We do not have an explanation for the slightly larger global movement observed with Q5, except perhaps a global shift in the SmartScope table positioning.

Conclusions

We have investigated the mechanical deformations of two modules with different glue patterns when cooled down. The most pronounced movements happened for the module furthest fiducials (F1, F4, F5, F8). We consider this to be the consequence of natural sensor bowing (warping) and lack of mechanical support at the far corners. The motion distance was different for each sensor (about 3, 17, 20 and 35 microns), which may be a reflection of their “individuality”. The inner fiducials (F2, F3, F6, F7) moved very little, less than 10 microns, compared to the global motion of the facings and Al plate. The LBL glue pattern is no different than the standard on in this respect. The result is natural, given that in the XY geometry the front and back glue dots overlap. This is true even for the furthest dots along the sensors gap, where the center-to-center distance is 1.2 mm (a typical glue dot diameter is 2 mm).